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Urayama et al.

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(54) **DEVELOPING DEVICE AND IMAGE FORMING APPARATUS**

(71) Applicant: **FUJI XEROX CO., LTD.**, Tokyo (JP)

(72) Inventors: **Kenta Urayama**, Kanagawa (JP); **Yasuaki Watanabe**, Kanagawa (JP); **Jun Abe**, Kanagawa (JP); **Tomoyuki Yoshii**, Kanagawa (JP); **Takashi Ochi**, Kanagawa (JP); **Shinji Okuyama**, Kanagawa (JP); **Fumiyuki Honda**, Kanagawa (JP); **Shiho Matsuda**, Kanagawa (JP)

(73) Assignee: **FUJI XEROX CO., LTD.**, Tokyo (JP)

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(22) Filed: **Jan. 13, 2016**

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G03G 15/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/0928*** (2013.01); ***G03G 15/0812*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0921; G03G 15/09; G03G 15/0812; G03G 15/0808; G03G 2215/0609
USPC 399/267, 277, 274
See application file for complete search history.

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Primary Examiner — Walter L Lindsay, Jr.
Assistant Examiner — Jessica L Eley
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

A developing device includes a developing sleeve and a regulation portion. The developing sleeve includes a magnetism generating portion to which magnetic poles are attached. The developing sleeve holds a developer on an outer circumferential surface. The regulation portion includes a magnetic plate. A first segment connecting a peak position of the magnetic pole disposed at a position facing the magnetic plate and an axial center of the developing sleeve has an angle, with respect to a second segment connecting the magnetic plate and the axial center, equal to or less than 7 degrees on a downstream side in a rotation direction of the developing sleeve and equal to or less than 6 degrees on an upstream side in the rotation direction. An angle of a half value width of the magnetic pole is equal to or greater than 41 degrees to equal to or less than 52 degrees.

5 Claims, 8 Drawing Sheets

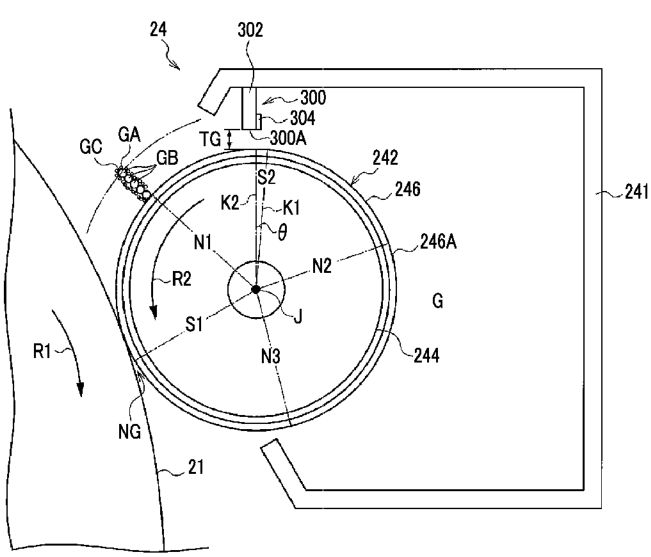
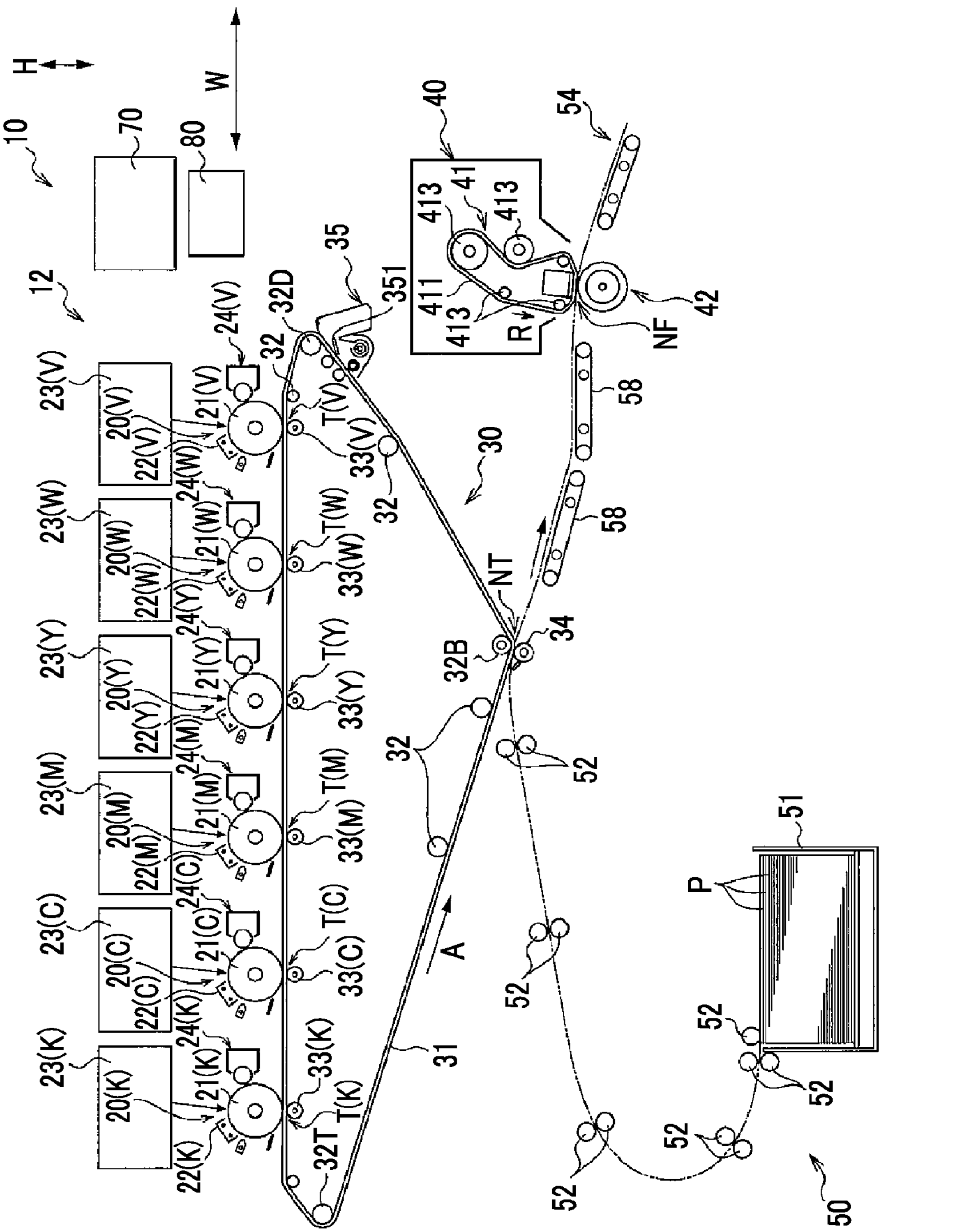


FIG. 1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12
H
W
70
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23(C)
23(M)
23(Y)
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T(W)
T(V)
32T
31
A
32
32B
32D
NT
34
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351
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40
41
411
413
R
NF
42
54
58
52
51
P
50

FIG. 2

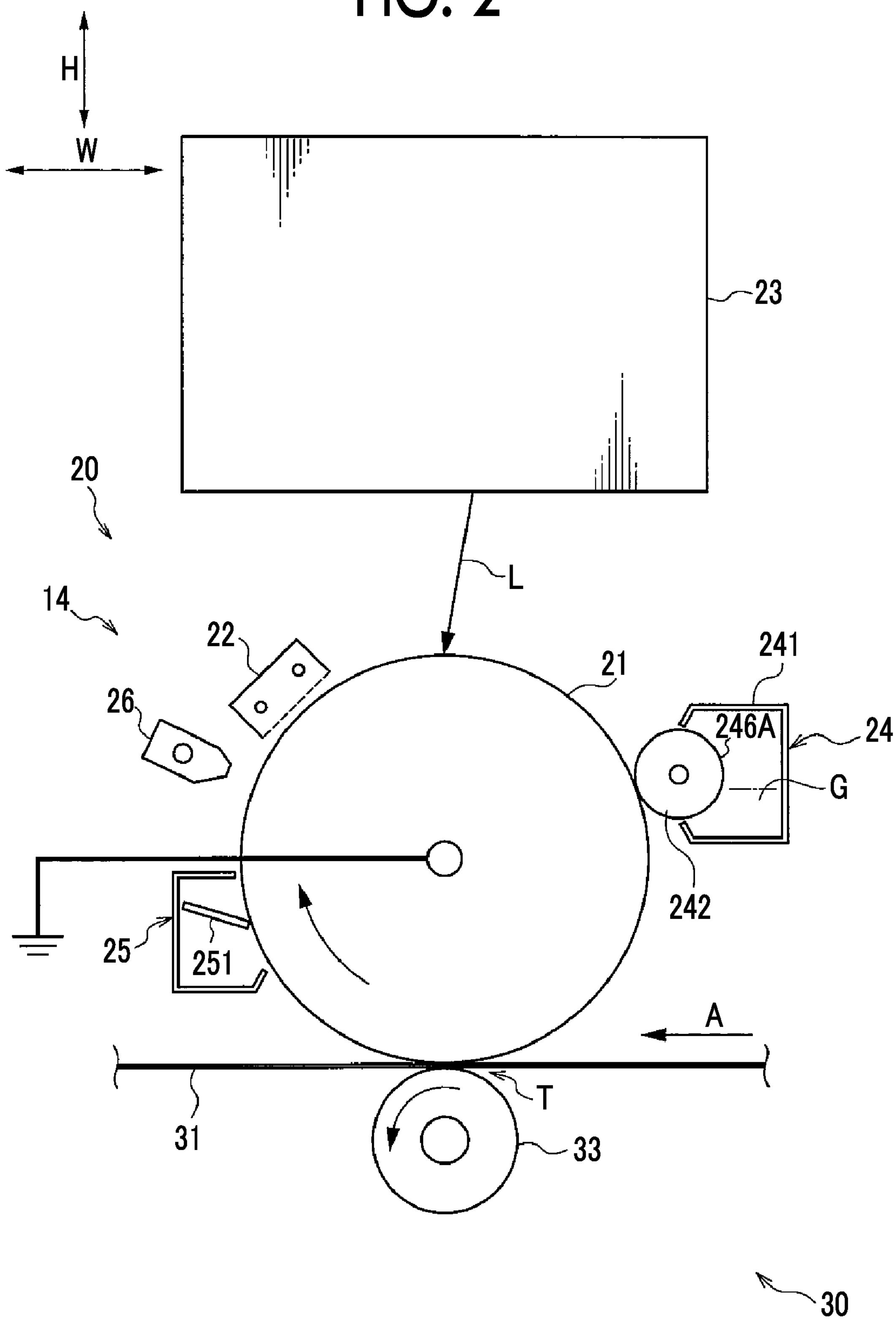
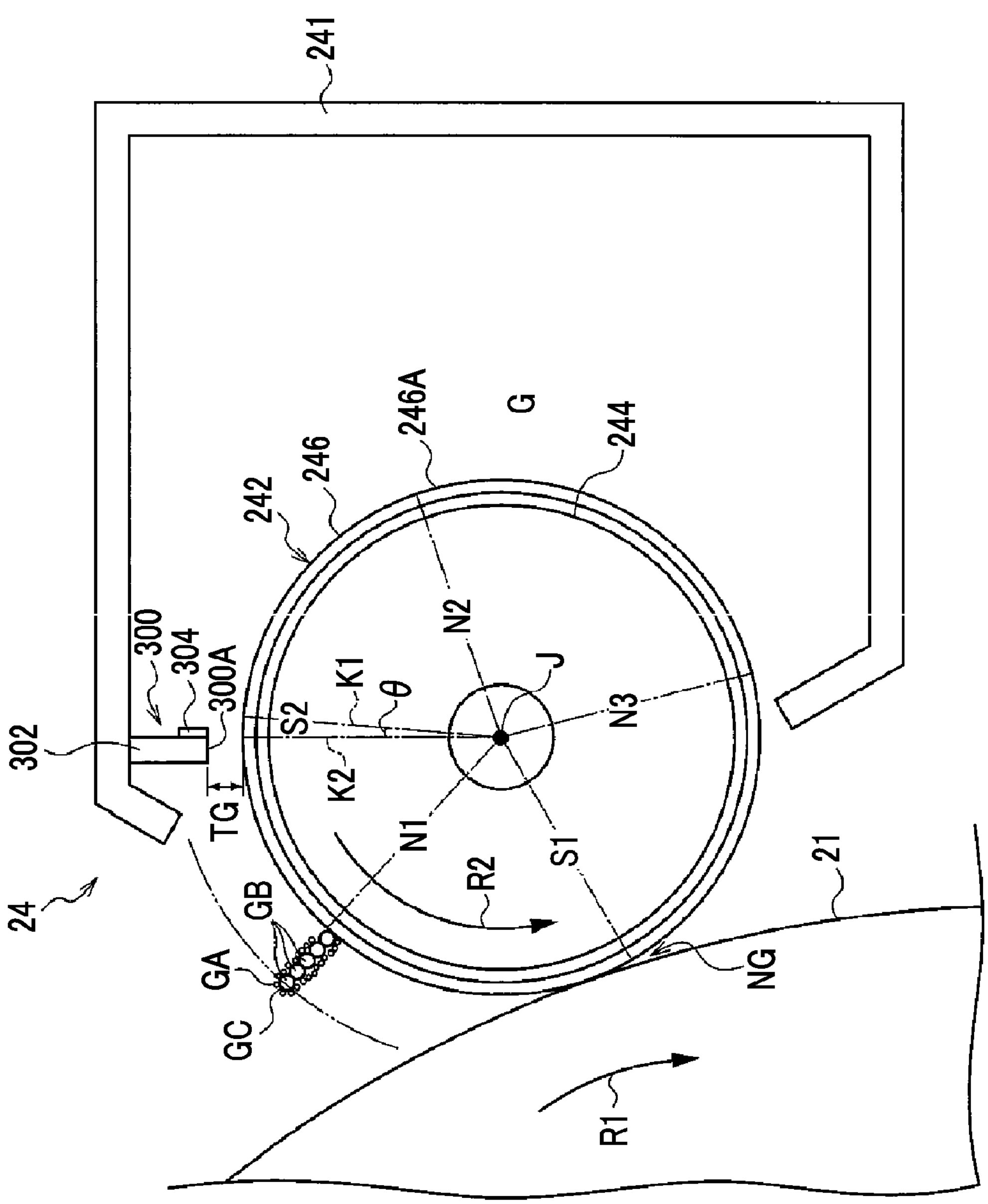


FIG. 3



241
G
246A
244
246
242
300
304
300A
302
K1
θ
S2
N2
J
N3
K2
TG
N1
S1
24
R2
GB
GA
GC
NG
21
R1

FIG. 4

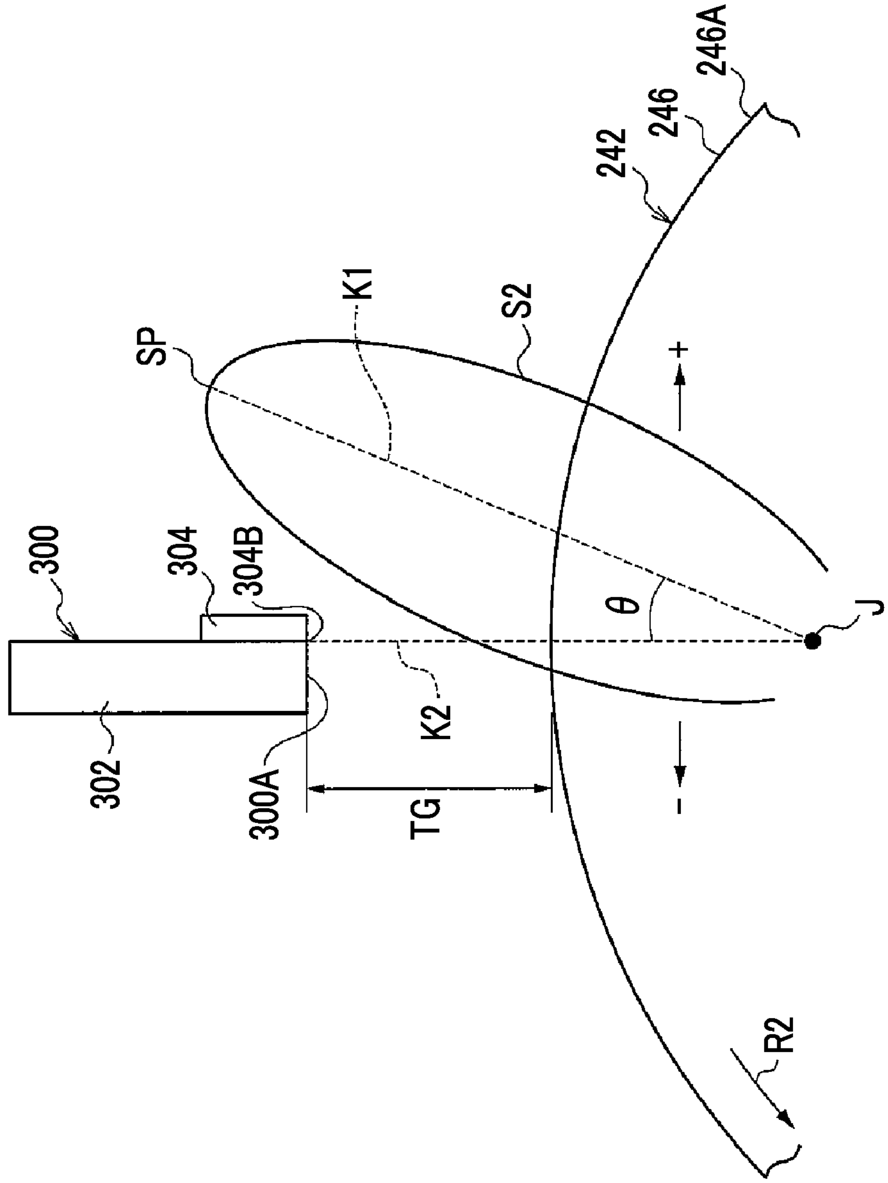


FIG. 5

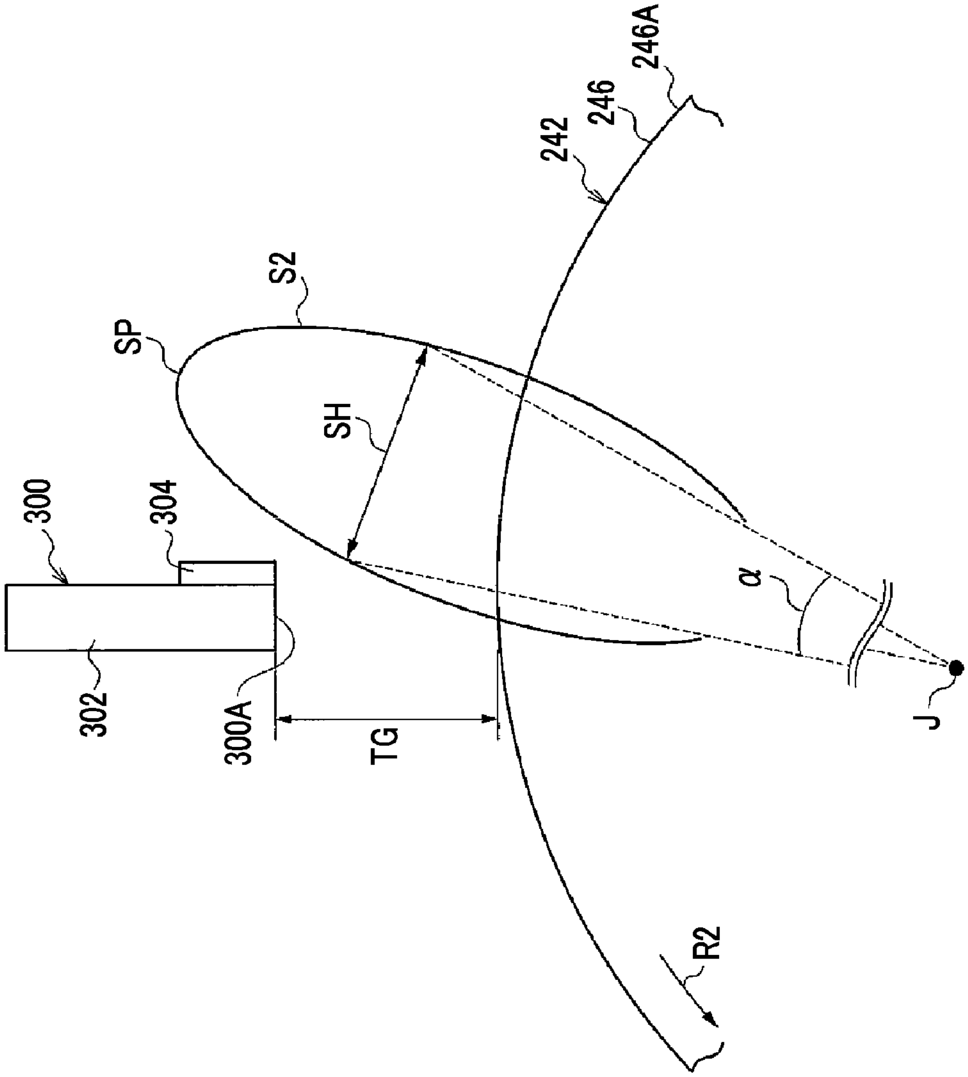


FIG. 6

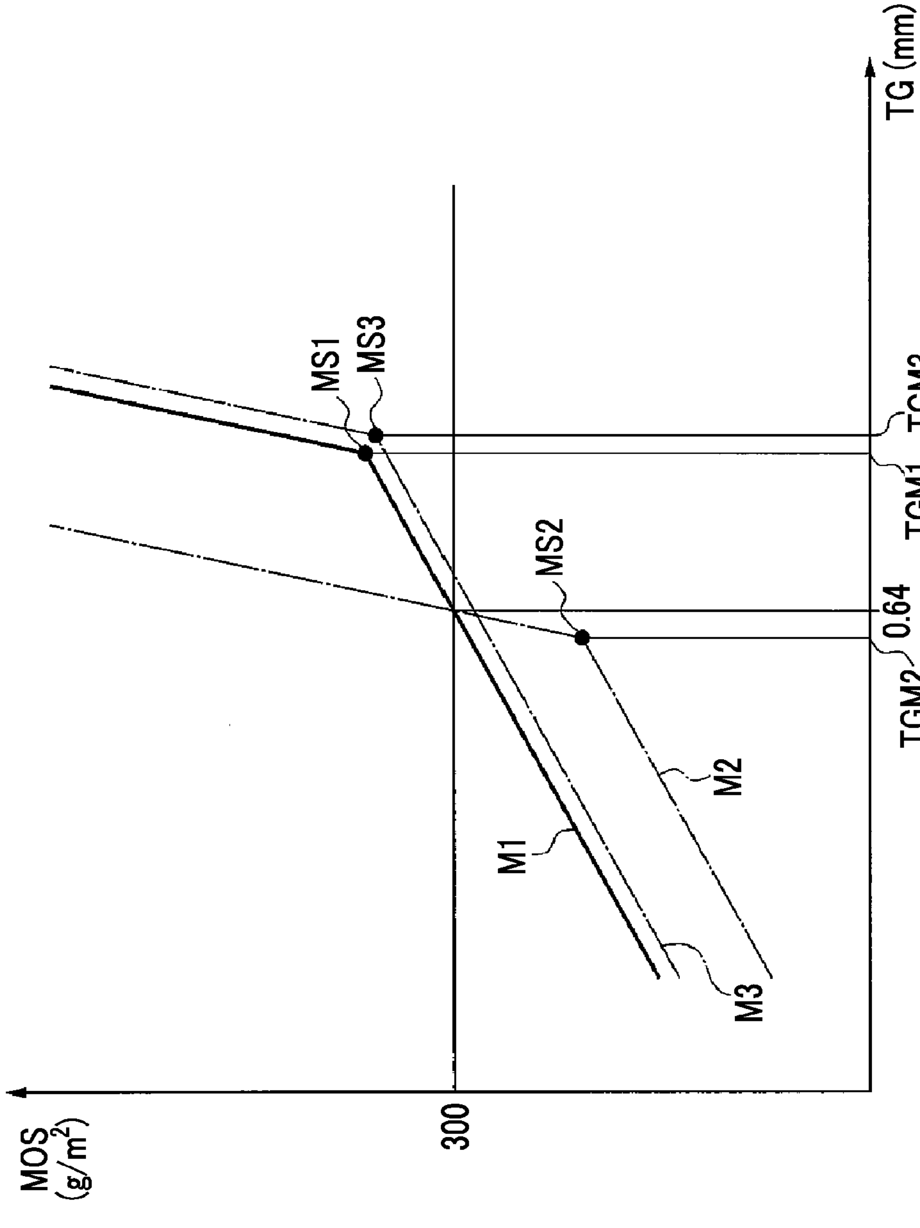


FIG. 7

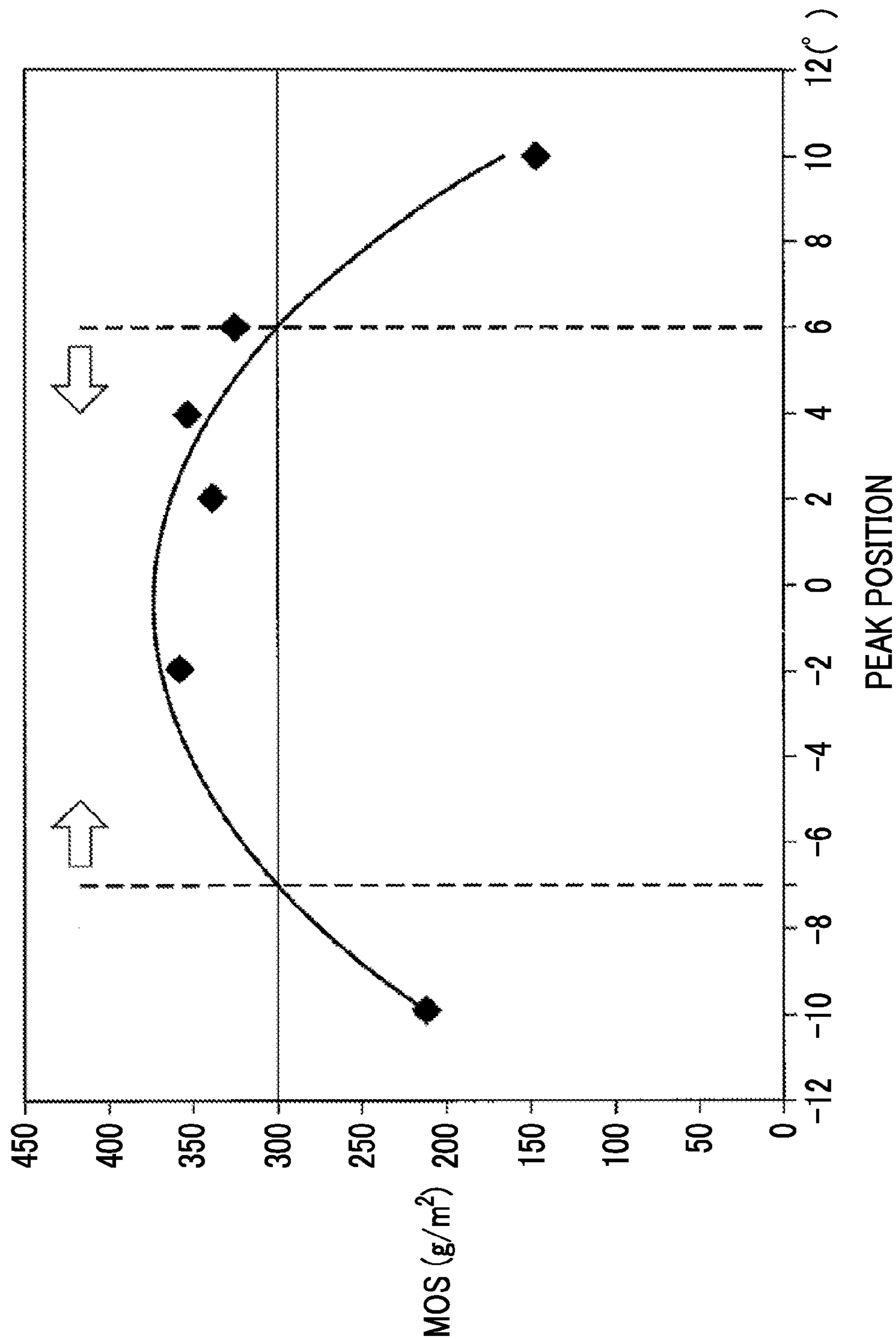
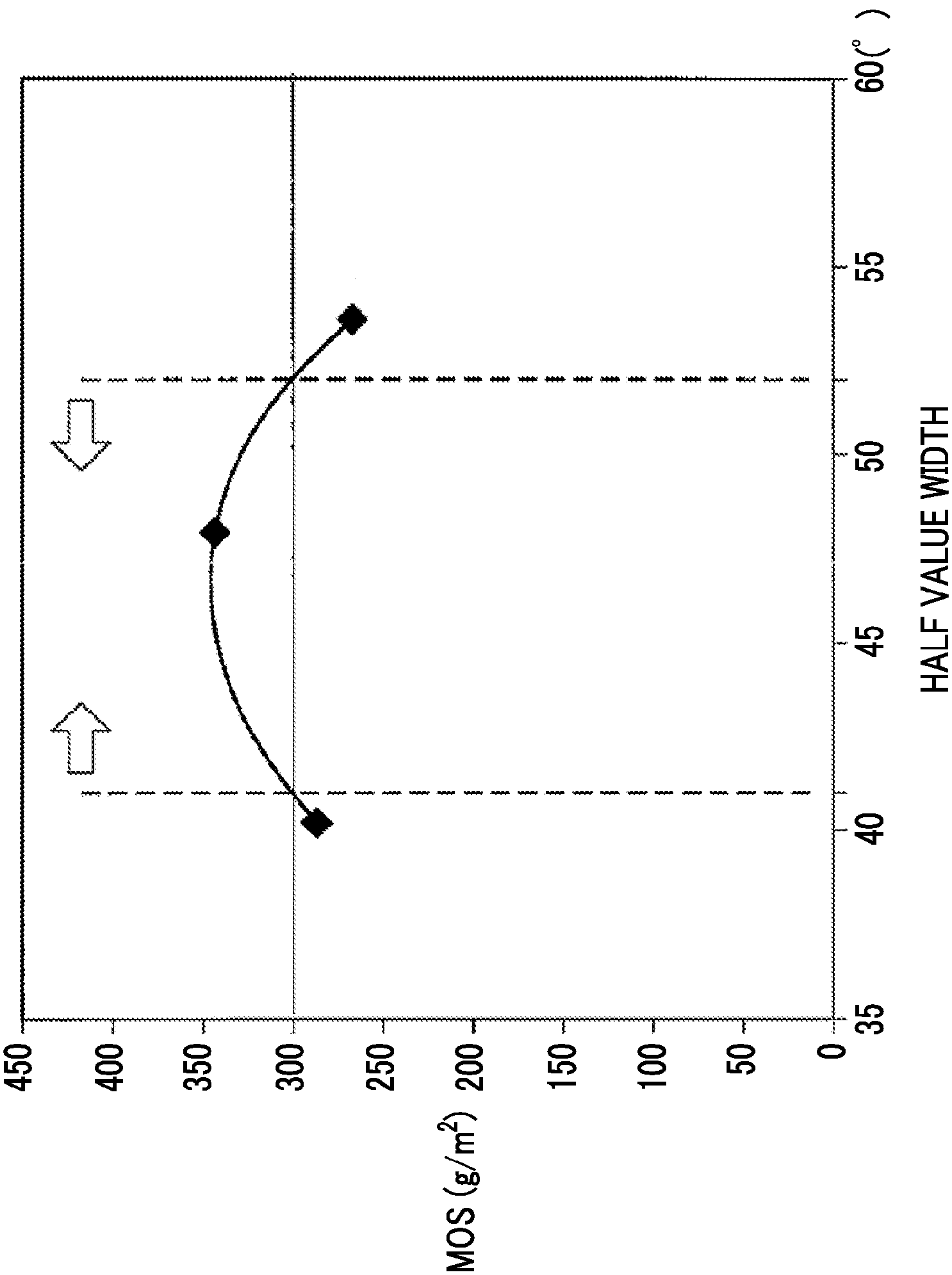

MOS (g/m²)
450
400
350
300
250
200
150
100
50
0
−12
−10
−8
−6
−4
−2
0
2
4
6
8
10
12(°)
PEAK POSITION

FIG. 8


MOS (g/m^2)
0
50
100
150
200
250
300
350
400
450
35
40
45
50
55
60(°)
HALF VALUE WIDTH

DEVELOPING DEVICE AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 USC 119 from Japanese Patent Application No. 2015-137521 filed Jul. 9, 2015.

BACKGROUND

Technical Field

The present invention relates to a developing device and an image forming apparatus.

SUMMARY

According to an aspect of the invention, a developing device includes a developing sleeve and a regulation portion. The developing sleeve includes a magnetism generating portion therein. A plurality of magnetic poles is attached to the magnetism generating portion in a circumferential direction. The developing sleeve holds a developer on an outer circumferential surface thereof. The developer contains a toner and magnetic carriers having a volume average diameter equal to or greater than 25 μm and equal to or less than 35 μm. The developing sleeve is rotatably driven. The regulation portion is disposed at a distance from the outer circumferential surface of the developing sleeve and that includes a magnetic plate. A first segment connecting a peak position of the magnetic pole disposed at a position where the magnetic pole faces the magnetic plate and an axial center of the developing sleeve has an angle, with respect to a second segment connecting the magnetic plate and the axial center, equal to or less than 7 degrees on a downstream side in a rotation direction of the developing sleeve and equal to or less than 6 degrees on an upstream side in the rotation direction of the developing sleep. An angle of a half value width of the magnetic pole is equal to or greater than 41 degrees to equal to or less than 52 degrees.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

FIG. **1** is a configuration diagram illustrating the configuration of an image forming apparatus according to an exemplary embodiment;

FIG. **2** is a configuration diagram illustrating the configuration of a toner image forming section according to the present exemplary embodiment;

FIG. **3** is a configuration diagram illustrating the configuration of a developing device of the toner image forming section shown in FIG. **2**;

FIG. **4** is a configuration diagram illustrating a peak position of a regulation magnetic pole;

FIG. **5** is a configuration diagram illustrating a half value width of a regulation magnetic pole;

FIG. **6** is a graph illustrating a relationship between an amount of held developer (MOS) and an interval TG;

FIG. **7** is a graph illustrating a relationship between the amount of held developer (MOS) and a peak position of the regulation magnetic pole; and

FIG. **8** is a graph illustrating a relationship between the amount of held developer (MOS) and a half value width of the regulation magnetic pole.

DETAILED DESCRIPTION

An example of an image forming apparatus according to an exemplary embodiment of the present invention will now be described. Meanwhile, an arrow H shown in each diagram indicates a vertical direction, and an arrow W indicates a horizontal direction and an apparatus width direction.

<Configuration of Image Forming Apparatus>

FIG. **1** is a schematic diagram illustrating a configuration when an image forming apparatus **10** is seen from the front side. As illustrated in the drawing, the image forming apparatus **10** is configured to include an image forming section **12** that forms an image on a paper surface (sheet surface) of a sheet-shaped recording medium (sheet member) P such as paper by an electrophotographic process, a transport device **50** that transports a recording medium P, a control section **70** that controls the operation of each section of the image forming apparatus **10**, and a power supply section **80** that supplies power to each component.

[Transport Device]

As illustrated in FIG. **1**, the transport device **50** includes a container **51** that accommodates the recording medium P, and plural transport rollers **52** that transport the recording medium P to a secondary transfer position NT to be described later from the container **51**. Further, the transport device **50** includes plural transport belts **58** transport the recording medium P to a fixing device **40** from the secondary transfer position NT, and a transport belt **54** that transports the recording medium P toward an exit section (not shown) of the recording medium P from the fixing device **40**.

[Image Forming Section]

The image forming section **12** includes a toner image forming section **20** that forms a toner image, a transfer device **30** that transfers the toner image formed by the toner image forming section **20** to the recording medium P, and the fixing device **40** that heats and presses the toner image transferred to the recording medium P to thereby fix the toner image onto the recording medium P.

The plural toner image forming sections **20** are provided so as to form a toner image for each color. In the exemplary embodiment, toner image forming sections **20**V, **20**W, **20**Y, **20**M, **20**C, and **20**K of a total of six colors of a first special color (V), a second special color (W), yellow (Y), magenta (M), cyan (C), and black (K) are provided. The signs of (V), (W), (Y), (M), (C), and (K) illustrated in FIG. **1** indicate the above-mentioned colors.

Meanwhile, in the present exemplary embodiment, the first special color (V) and the second special color (W) are corporate colors specific to a user.

[Toner Image Forming Section]

As illustrated in FIG. **1**, the toner image forming sections **20** of the respective colors are basically configured in the same manner except for a toner to be used. Specifically, as illustrated in FIG. **2**, each of the toner image forming sections **20** of the respective colors includes a photoconductor drum **21** which is rotated clockwise in FIG. **2**, and a charger **22** that charges the photoconductor drum **21**. Further, each of the toner image forming sections **20** of the respective colors includes an exposure device **23** that forms an electrostatic latent image on the photoconductor drum **21** by exposing the photoconductor drum **21** charged by the charger **22**, a developing device **24** that forms a toner image by developing the electrostatic latent image formed on the photoconductor drum **21** by the exposure device **23**, a cleaning device **25**, and a static eliminator **26**.

[Developing Device]

As illustrated in FIG. **2**, the developing device **24** is configured to include a container **241** that accommodates a developer G, and a developing roller **242**. A developing bias voltage is applied to the developing roller **242**, and thus the electrostatic latent image formed on the outer circumferential surface of the photoconductor drum **21** is developed as a toner image due to a potential difference generated between the developing roller **242** and the photoconductor drum **21**.

Meanwhile, the structure of the developing device **24** and the developer G will be described later.

(Cleaning Device)

The cleaning device **25** includes a blade **251** that scrapes off a toner remaining on the surface of the photoconductor drum **21** after a toner image is transferred to the transfer device **30**, from the surface of the photoconductor drum **21**.

[Transfer Device]

The transfer device **30** primarily transfers toner images of the photoconductor drums **21** of the respective colors to a transfer belt **31** (intermediate transfer body) at respective primary transfer positions T to superimpose the toner images thereon, and secondarily transfers the superimposed toner images to a recording medium P at the secondary transfer position NT. Specifically, the transfer device **30** includes the transfer belt **31**, a primary transfer roller **33**, and a secondary transfer roller **34** as an example of a transfer member.

(Transfer Belt)

As illustrated in FIG. **1**, the transfer belt **31** has an endless shape, and is wound around plural rollers **32**. Among the plural rollers **32**, a roller **32**D functions as a driving roller that circulates the transfer belt **31** in a direction of an arrow A by motive power of a motor not shown in the drawing. The transfer belt **31** circulates in the direction of the arrow A to thereby transport a toner image, primarily transferred at the respective primary transfer positions T and superimposed thereon, to the secondary transfer position NT.

In addition, among the plural rollers **32**, a roller **32**T functions as a tension applying roller that applies tension to the transfer belt **31**. Among the plural rollers **32**, a roller **32**B functions as an opposite roller **32**B facing the secondary transfer roller **34**.

A cleaning device **35** that cleans the transfer belt **31** is disposed on a downstream side of the secondary transfer position NT and on an upstream side of the primary transfer position T (V) in a circulation direction (direction of the arrow A) of the transfer belt **31**. The cleaning device **35** includes a blade **351** that scrapes off a toner remaining on the surface of the transfer belt **31** from the surface of the transfer belt **31**.

(Primary Transfer Roller)

Each of the primary transfer rollers **33** is a roller that transfers a toner image on each of the photoconductor drums **21** to the transfer belt **31**, and is disposed on the inner side of the transfer belt **31**. Each of the primary transfer rollers **33** is disposed facing the photoconductor drum **21** of the corresponding color with the transfer belt **31** interposed therebetween. In addition, a primary transfer voltage having a polarity opposite to that of a toner is applied to each of the primary transfer rollers **33**, and thus the toner image formed on the photoconductor drum **21** is transferred to the transfer belt **31** at the primary transfer position T (also see FIG. **2**).

(Secondary Transfer Roller)

The secondary transfer roller **34** is a roller that transfers a toner image superimposed on the transfer belt **31** to the recording medium P. The secondary transfer roller **34** is disposed facing the opposite roll **32**B mentioned above with the transfer belt **31** interposed therebetween, and the secondary transfer roller **34** and the transfer belt **31** contacts with each other with a predetermined load. In this manner, a position between the secondary transfer roller **34** and the transfer belt **31** which contact in this manner serves as the secondary transfer position NT. The recording medium P is configured to be timely supplied to the secondary transfer position NT from the container **51**.

[Fixing Device]

The fixing device **40** fixes a toner image onto the recording medium P to which the toner image is transferred. Specifically, the fixing device **40** is configured to fix a toner image onto the recording medium P by heating and pressing the toner image at a fixing nip NF formed by a pressing roller **42** and a fixing belt **411** wound around plural rollers **413**.

[Image Forming Operation]

Next, outlines of a process of forming an image on a recording medium P by the image forming apparatus **10** and a post-treatment process will be described.

The control section **70** having received an image forming instruction operates the toner image forming section **20**, the transfer device **30**, and the fixing device **40**. In addition, the control section **70** operates the transport device **50** and the like in synchronization with the operations thereof.

The photoconductor drums **21** of the respective colors are charged by the charger **22** while rotating. In addition, the control section **70** transmits image data subjected to image processing by an image signal processing section to each of the exposure devices **23**. Each of the exposure devices **23** emits exposure light L (see FIG. **2**) in accordance with the image data to expose the charged photoconductor drum **21**. Thereby, an electrostatic latent image is formed on the outer circumferential surface of each of the photoconductor drums **21**. The electrostatic latent image formed on the photoconductor drum **21** is developed by the developing device **24**, toner images of a first special color (V), a second special color (W), yellow (Y), magenta (M), cyan (C), and black (K) are formed on the photoconductor drums **21** of the respective colors.

The toner images of the respective colors formed on the photoconductor drums **21** of the respective colors are sequentially primarily transferred to the circulating transfer belt **31** by the primary transfer rollers **33** of the respective colors at the respective primary transfer positions T. Thereby, a superimposition toner image obtained by superimposing the toner images of six colors on each other is formed on the transfer belt **31**. The superimposition toner image is transported to the secondary transfer position NT by the circulation of the transfer belt **31**. The recording medium P is supplied to the secondary transfer position NT by the transport roller **52** in accordance with a transport timing of the superimposition toner image. The superimposition toner image is secondarily transferred to the recording medium P from the transfer belt **31** at the secondary transfer position NT.

The recording medium P having the toner image secondarily transferred thereto is transported toward the fixing device **40** by a transport belt **58** while being sucked by negative pressure. The fixing device **40** applies heat and a pressing force to the recording medium P passing through the fixing nip NF. Thereby, the toner image transferred to the recording medium P is fixed onto the recording medium P.

The recording medium P having the toner image, fixed by the fixing device **40**, thereto is transported by the transport belt **54**, and is discharged to an exit section (not shown).

<Configuration of Major Part>

Next, the configuration of the major part of the present exemplary embodiment will be described.

[Developing Device]

As illustrated in FIG. **3**, the developing device **24** includes the developing roller **242**, and the developer G is accommodated in the container **241** of the developing device **24**. Meanwhile, in FIG. **3**, magnetic carriers GA, toners GB, and magnetic brushes GC which constitute the developer G to be described later are illustrated larger than their actual sizes.

The developing roller **242** is formed to have a structure in which a magnetism generating member **244** having plural magnetic poles attached to a cylindrical developing sleeve **246** is built thereinto.

The developing roller **242** is disposed facing the photoconductor drum **21** which is rotatably driven, and is rotated in a direction of an arrow R**2** which is a rotation direction opposite to a rotation direction R**1** of the photoconductor drum **21**. Meanwhile, in the developing roller **242** according to the present exemplary embodiment, only the developing sleeve **246** is rotated, and the magnetism generating member **244** inside the developing sleeve **246** is fixed without being rotated.

The developer G is a so-called two-component developer containing the magnetic carriers GA and the toners GB colored in corresponding color.

As described above, in the developing roller **242**, the magnetism generating member **244** is built into the developing sleeve **246**, and thus the developer G, more specifically, the magnetic carrier GA having the toners GB attached thereto is held on an outer circumferential surface **246**A of the developing sleeve **246** (developing roller **242**) by a magnetic force.

The developing device **24** is provided with a regulation portion **300** for regulating the amount of developer G (MOS to be described later) which is held on the outer circumferential surface **246**A on the developing sleeve **246** (developing roller **242**). Meanwhile, the regulation portion **300** will be described later.

In the developing device **24** configured in this manner, the amount of developer G held by the developing sleeve **246** (developing roller **242**) is regulated by the developer striking the regulation portion **300**, and the developer G having the regulated amount is transported to a developing portion NG which is a portion where the developer G contacts with the photoconductor drum **21**.

In the developing device **24**, an electrostatic latent image on the photoconductor drum **21** is developed by a so-called reversal developing method in the developing portion NG, and is developed as a toner image. Meanwhile, a developing bias is applied to the developing roller **242** by the power supply section **80** (see FIG. **1**).

[Regulation Portion]

The regulation portion **300** extends in an axial direction of the developing roller **242**. In addition, a tip portion **300**A of the regulation portion **300** is disposed with an interval TG (trimer gap) determined in advance with respect to the outer circumferential surface **246**A of the developing sleeve **246** of the developing roller **242**. Meanwhile, in the present exemplary embodiment, the interval TG is set to 0.64±0.07 mm.

The regulation portion **300** is configured with a supporting portion **302** bonded to the container **241** and a metal magnetic plate **304** bonded to the supporting portion **302**. Meanwhile, a tip portion of the supporting portion **302** and a tip portion of the magnetic plate **304** are formed flush with each other or formed substantially flush with each other, and thus will be referred to as the tip portion **300**A as described above without being distinguished from each other.

[Developer]

As illustrated in FIG. **3**, the developer G is configured to include the magnetic carriers GA and the toners GB. The toner GB according to the present exemplary embodiment is configured to include a binder resin, an internal additive dispersed in the binder resin, and an external additive dispersed on the surface of the binder resin.

The magnetic carrier GA according to the present exemplary embodiment has a particle size larger than that of the toner GB, and includes a magnetic material such as ferrite particles.

The magnetic carrier GA used in the present exemplary embodiment is a small-diameter carrier having a volume average diameter equal to or greater than 25 μm and equal to or less than 35 μm. Meanwhile, the volume average diameter of the magnetic carrier GA according to the present exemplary embodiment is 30 μm. In addition, the weight susceptibility of the magnetic carrier GA is 41.8 emu/g to 45.7 emu/g when an external magnetic field is 65 mT (corresponding to the center of design of the regulation magnetic pole S**2** to be described later).

[Amount of Held Developer (Amount of Developer)]

A design value (desired amount of retention) of the amount of held developer G (amount of developer, mass of sleeve (MOS)) which is regulated by the developer striking the regulation portion **300** of the present exemplary embodiment. In other words, a design value of the amount of developer G, on a downstream side of the regulation portion **300** in the rotation direction (direction of the arrow R**2**), held on the developing sleeve **246** is 300 g/m^2.

[Developing Roller]

The developing roller **242** includes the developing sleeve **246**, the magnetism generating member **244** which is built into the developing sleeve **246**. Meanwhile, as described above, in the developing roller **242** according to the present exemplary embodiment, only the developing sleeve **246** is rotated, and the magnetism generating member **244** inside the developing sleeve **246** is fixed without being rotated.

The developing sleeve **246** constituting the developing roller **242** is configured as a metal pipe, and contains stainless steel (SUS) in the present exemplary embodiment. In addition, the outer circumferential surface **246**A of the developing sleeve **246** is subjected to sandblasting, and the ten-point average roughness Rz of the outer circumferential surface **246**A is set to be in a range of 14 μm to 22 μm.

The magnetism generating member **244** constituting the developing roller **242** is a magnet roller obtained by molding powder which is a magnetic material such as ferrite or a rare earth magnet alloy into a columnar shape or a cylindrical shape, and is formed by sintering while being magnetized so that an N pole and an S pole are disposed in a pattern determined in advance.

A developing magnetic pole S**1** is disposed at a position corresponding to the developing portion NG, and magnetic poles are disposed on a downstream side of the developing magnetic pole S**1** in a rotation direction along a rotation direction R**2** of the developing roller **242** (developing sleeve **246**) in the order of a pick-off magnetic pole N**3**, a pick-up magnetic pole N**2**, a regulation magnetic pole S**2**, and a transport magnetic pole N**1**.

The regulation magnetic pole S**2** is disposed at a position facing the regulation portion **300**. In addition, the magnetic flux density of the regulation magnetic pole S**2** is set to 65 mT±5 mT.

As illustrated in FIG. **4**, in the regulation magnetic pole S**2**, an angle θ formed by a first segment K**1**, connecting a peak position SP of the magnetic flux density and an axial center J of the developing sleeve **246** (developing roller **242**), and a second segment K**2**, connecting a corner portion **304**B on the supporting portion **302** side in the lower end portion of the magnetic plate **304** and the axial center J, is set to be equal to or greater than −7 degrees and equal to or less than +6 degrees (also see FIG. **3**). The rotation direction R**2** side is a negative side. In other words, the second segment K**2** is set to be in a range of equal to or less than 7 degrees on a downstream side in a rotation direction with respect to the first segment K**1** and equal to or less than 6 degrees on an upstream side. Meanwhile, in the present exemplary embodiment, the angle θ of the peak position SP is set to 2.0 degrees.

Meanwhile, in FIG. **4**, the position and angle θ of the actual axial center J are not accurately illustrated.

As illustrated in FIG. **5**, an angle α of a half value width SH of the regulation magnetic pole S**2** is set to be equal to or greater than 41 degrees and equal to or less than 52 degrees. Meanwhile, in the present exemplary embodiment, the angle α of the half value width SH is set to 48.0 degrees.

The half value width SH refers to an angle width of a portion indicating a half value of the highest normal magnetic flux density (vertex) of a magnetic flux density distribution curve in a normal direction in a magnetic pole (regulation magnetic pole S**2** in the present exemplary embodiment).

Here, FIG. **7** is a graph illustrating a relationship between an angle θ at the peak position SP of the regulation magnetic pole S**2** and the amount of held developer G (MOS). Meanwhile, an angle α of the half value width SH is 48.0 degrees.

As described above, a design value (desired amount of retention) of the amount of held developer G which is regulated by the developer G, held by the developing sleeve **246** (developing roller **242**) in the present exemplary embodiment, striking the regulation portion **300** in the present exemplary embodiment is 300 g/m^2. The angle θ of the peak position SP of the regulation magnetic pole S**2** having the amount of retention (MOS) set to equal to or greater than 300 g/m^2 is equal to or greater than −7 degrees and equal to or less than +6 degrees. Accordingly, as described above using FIG. **4**, the angle θ of the peak position SP of the regulation magnetic pole S**2** is set to be equal to or greater than −7 degrees and equal to or less than +6 degrees.

FIG. **8** is a graph illustrating a relationship between an angle α of the half value width SH of the regulation magnetic pole S**2** and the amount of held developer G (MOS). The angle θ of the peak position SP is 2.0 degrees.

As described above, a design value (desired amount of retention) of the amount of developer G held by the developing sleeve **246** (developing roller **242**) of the exemplary embodiment is 300 g/m^2. In addition, an angle α of the half value width SH of the regulation magnetic pole S**2** having the amount of retention (MOS) equal to or greater than 300 g/m^2 is equal to or larger than 41 degrees and equal to or less than 52 degrees. Accordingly, as described above using FIG. **5**, the angle α of the half value width SH of the regulation magnetic pole S**2** is set to be equal to or larger than 41 degrees and equal to or less than 52 degrees.

<Operation>

Next, the operation of the present exemplary embodiment will be described.

A solid line M**1** shown in FIG. **6** is a graph indicating a relationship between the amount of held developer G (MOS) and an interval TG between the regulation portion **300** and the outer circumferential surface **246**A of the developing sleeve **246** of the developing roller **242** in the developing device **24** according to the present exemplary embodiment. In this manner, the amount of held developer G increases as the interval TG gets larger, and has an inflection point MS**1** at which the amount of retention increases suddenly when a predetermined interval TG is set. Meanwhile, the interval is referred to as TGM**1**.

Although a fluctuation range of the amount of held developer G with respect to a fluctuation in the interval TG in equal to or less than the interval TG at the inflection point MS**1** is small, a fluctuation range of the amount of held developer G with respect to a fluctuation in the interval TG in a case of being larger than the interval TG at the inflection point MS**1** is increased. An increase in the fluctuation range of the amount of held developer G (MOS) may result in defective image quality (wavelike shading).

Here, the cause of the generation of the inflection point MS**1** will be described.

A line of magnetic force is generated between the magnetic plate **304** and the regulation magnetic pole S**2** by the magnetic plate **304** provided in the regulation portion **300**, while results in a state where magnetic carriers GA are continuously connected to each other along the line of magnetic force, thereby exhibiting a shielding effect. However, a magnetic force decreases as the interval TG increases. When the interval is larger than the predetermined interval TG (TGM**1**), a state where the magnetic carriers GA are continuously connected to each other is not maintained. Thus, a shielding effect is reduced. For this reason, it is considered that a fluctuation range of the amount of held developer G (MOS) is increased.

In the present exemplary embodiment, an angle θ formed by the first segment K**1**, connecting the peak position SP of the regulation magnetic pole S**2** and the axial center J of the developing sleeve **246** (developing roller **242**), and the second segment K**2** connecting the magnetic plate **304** and the axial center J is set to be equal to or greater than −7 degrees and equal to or less than +6 degrees as illustrated in FIG. **4**, and an angle α of the half value width SH of the regulation magnetic pole S**2** is set to be equal to or larger than 41 degrees and equal to or less than 52 degrees as illustrated in FIG. **5**.

In addition, an interval TG in which a design value of the amount of held developer G (MOS) is set to 300 g/m^2 is 0.64 mm, which is equal to or less than the interval TGM**1** at the inflection point MS**1** as illustrated in FIG. **6**, and thus a fluctuation range of the amount of retention with respect to a fluctuation in the interval TG is small. Accordingly, the occurrence of defective image quality (wavelike shading) due to a large fluctuation range of the amount of held developer G is suppressed.

Here, a dashed line M**2** in FIG. **6** is a graph indicating a relationship between the amount of held developer G (MOS) and an interval TG according to a first comparative example in which an angle θ of the peak position SP falls outside a range of from −7 degrees to +6 degrees and an angle α of the half value width SH of the regulation magnetic pole S**2** falls outside a range of from 41 degrees to 52 degrees. Meanwhile, the other conditions such as a volume average diameter of a magnetic carrier GA are the same as those in the present exemplary embodiment.

In addition, a two-dot chain line M**3** in FIG. **6** is a graph indicating a relationship between the amount of held developer G (MOS) and an interval TG according to a second comparative example in which an angle θ of the peak position SP falls outside a range of from −7 degrees to +6 degrees, an angle α of the half value width SH of the regulation magnetic pole S**2** falls outside a range of from 41 degrees to 52 degrees, and a large-diameter magnetic carrier GA having a volume average diameter of greater than 35 μm is used.

In the case of the first comparative example (M**2**), regarding a design value of the amount of held developer G (MOS), an interval TG of 0.64 mm in which 300 g/m^2 is set is larger than TGM**2** in which an inflection point MS**2** is set, and has a large fluctuation range of the amount of retention with respect to a fluctuation in the interval TG.

In the case of the second comparative example (M**3**), regarding a design value of the amount of held developer G (MOS), an interval TG of 0.64 mm in which 300 g/m^2 is set is equal to or less than TGM**3** in which an inflection point MS**3** is set, and has a small fluctuation range of the amount of retention with respect to a fluctuation in the interval TG.

As in the second comparative example, in a case where the magnetic carrier GA of the developer G is a large-diameter carrier greater than 35 μm, an interval TG**3** at an inflection point MS**3** is substantially the same as the interval TG**1** at the inflection point MS**1** according to the present exemplary embodiment even when an angle θ of the peak position SP of the regulation magnetic pole S**2** falls outside a range of from −7 degrees to +6 degrees and an angle α of the half value width SH of the regulation magnetic pole S**2** falls outside a range of from 41 degrees to 52 degrees.

However, as in the first comparative example, in a case where the magnetic carrier GA of the developer G is a small-diameter carrier which is the same as in the present exemplary embodiment, with regard to the interval TG**2** at the inflection point MS**2**, an interval TG of 0.64 mm in which 300 g/m^2 is larger than TGM**2** in which the inflection point MS**2** is set, when an angle θ of the peak position SP of the regulation magnetic pole S**2** falls outside a range of from −7 degrees to +6 degrees and an angle α of the half value width SH of the regulation magnetic pole S**2** falls outside a range of from 41 degrees to 52 degrees.

In other words, even when the peak position SP of the regulation magnetic pole S**2** and the half value width SH fall outside a range in the present exemplary embodiment, a fluctuation in the amount of held developer G is small in a case of a large-diameter magnetic carrier GA, but a fluctuation range of the amount of retention is increased in the case of changing to a small-diameter magnetic carrier GA.

Consequently, in the present exemplary embodiment, as described above, an angle θ of the peak position SP of the regulation magnetic pole S**2** is set to be equal to or larger than −7 degrees and equal to or less than +6 degrees, and an angle α of the half value width SH of the regulation magnetic pole S**2** is set to be equal to or larger than 41 degrees and equal to or less than 52 degrees, and thus a reduction in a fluctuation in the amount of held developer G (MOS) is realized even when a small-diameter magnetic carrier GA is used.

Meanwhile, it is also possible to move an inflection point by increasing the magnetic force of the regulation magnetic pole S**2**. However, in the developing device **24** according to the present exemplary embodiment, it is not possible to sufficiently increase an inflection point even when the magnetic force of the regulation magnetic pole S**2** is increased from 65 mT to 80 mT.

In addition, an increase in the magnetic force of the regulation magnetic pole S**2** results in a rise in a driving torque of the developing roller **242**. For example, when a magnetic force is increased up to 80 mT, 0.241 N·m (2.45 kgf·cm) is set, but 0.181 N·m (1.85 kgf·cm) is set in the case of 65 mT which is a magnetic force in the present exemplary embodiment.

In addition, costs to be incurred are lower in a case of a small-diameter magnetic carrier GA than a large-diameter magnetic carrier GA.

Accordingly, as described above, a peak position SP and a half value width SH of the regulation magnetic pole S**2** are set, and thus it is possible to suppress the degradation of image quality by reducing a fluctuation in the amount of held developer G (MOS), to suppress a rise in a driving torque of the developing roller **242**, and to reduce running costs even when a small-diameter magnetic carrier GA is used.

In addition, the outer circumferential surface **246**A of the developing sleeve **246** of the developing roller **242** according to the present exemplary embodiment is subjected to blasting. Accordingly, a decrease in the amount of held developer G due to a change, with time, of the outer circumferential surface **246**A of the developing sleeve **246** (abrasion due to friction) is small as compared to a case where a V-groove is formed in the outer circumferential surface **246**A of the developing sleeve **246**.

OTHERS

In addition, the present invention is not limited to the above-described exemplary embodiment.

The outer circumferential surface **246**A of the developing sleeve **246** of the developing roller **242** according to the above-described exemplary embodiment is subjected to blasting, but is not limited thereto. Accordingly, a V-groove may be formed in the outer circumferential surface **246**A of the developing sleeve **246**, or may not be processed.

The image forming apparatus may be configured in various ways without being limited to the configuration of the above-described exemplary embodiment. Further, it is needless to say that the present invention can be implemented in various modes without departing from the scope of the invention.

The foregoing description of the exemplary embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.

What is claimed is:

1. A developing device comprising:

a developing sleeve that

includes a magnetism generating portion therein, a plurality of magnetic poles being attached to the magnetism generating portion in a circumferential direction,

holds a developer on an outer circumferential surface thereof, the developer containing a toner and magnetic carriers having a volume average diameter equal to or greater than 25 μm and equal to or less than 35 μm, and

is rotatably driven; and

a regulation portion that is disposed at a distance from the outer circumferential surface of the developing sleeve and that includes a magnetic plate,

wherein a first segment connecting a peak position of the magnetic pole disposed at a position where the magnetic pole faces the magnetic plate and an axial center of the developing sleeve has an angle, with respect to a second segment connecting the magnetic plate and the axial center, equal to or less than 7 degrees on a downstream side in a rotation direction of the developing sleeve and equal to or less than 6 degrees on an upstream side in the rotation direction of the developing sleep, and

wherein an angle of a half value width of the magnetic pole is equal to or greater than 41 degrees to equal to or less than 52 degrees.

2. The developing device according to claim **1**, wherein the outer circumferential surface of the developing sleeve is subjected to blasting.

3. An image forming apparatus comprising:

an image forming section that forms a toner image on an image holding body by the developing device according to claim **1**, and transfers the toner image formed on the image holding body to a recording medium; and

a fixing device that fixes the toner image transferred to the recording medium.

4. An image forming apparatus comprising:

an image forming section that forms a toner image on an image holding body by the developing device according to claim **2**, and transfers the toner image formed on the image holding body to a recording medium; and

a fixing device that fixes the toner image transferred to the recording medium.

5. A developing device comprising:

a developing sleeve that

includes a magnetism generating portion therein, the magnetism generating portion having a plurality of magnetic poles,

is configured to hold a developer on an outer circumferential surface thereof, the developer containing a toner and magnetic carriers having a volume average diameter equal to or greater than 25 μm and equal to or less than 35 μm, and

is rotatably driven; and

a regulation portion that is disposed at a distance from the outer circumferential surface of the developing sleeve and that includes a magnetic plate, wherein

one of the magnetic pole faces the magnetic plate,

a first segment connects a peak position where a magnetic flux density of the one magnetic pole takes a maximum value and an axial center of the developing sleeve,

a second segment connects the one magnetic plate and the axial center,

in a section view taken along a plane perpendicular to an axis of the developing sleeve, the magnetic flux density of the one magnetic pole takes a half maximum value at half maximum value positions,

if the peak position is at downstream of the second segment in a rotation direction of the developing sleeve, an angle between the first and second segments is equal to or larger than 0 degree and equal to or less than 7 degrees,

if the peak position is at upstream of the second segment in the rotation direction of the developing sleeve, the angle between the first and second segments is equal to or larger than 0 degree and equal to or less than 6 degrees, and

a maximum angle between (i) a segment connecting one of the half maximum value positions and the axial center of the developing sleeve and (ii) a segment connecting another one of the half maximum value positions and the axial center of the developing sleeve is equal to or larger than 41 degrees to equal to or less than 52 degrees.

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